Maintaining Productive Patterns of Teacher-Student Interactions in Mathematics Classrooms

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In preparing to study teacher-student interactions in mathematics classrooms in Iran, this paper as a literature review considers relevant mathematics education literature. I explore which aspects of classroom environments orient researchers to judge patterns of classroom interactions as productive. I examine patterns of classroom interactions that were empirically linked to student understanding. This paper highlights the importance of productive patterns of teacher-student interactions in promoting student learning, examining authoritative and dialogic teaching as two opposing approaches.

Introduction

Researchers, who adopt a sociocultural perspective on learning (see, for example, Goos, 2004), view classroom interactions as the means that facilitate student learning. The ways in which the teacher and the students interact with each other matter and give rise to potentially very different classroom mathematical practices and thus shape student learning. According to Lave and Wenger (1991), learning is seen as a social event in which teachers and students give meaning to the classroom interactions, where student participation is the focus. Similarly, Loef Frank, Kazcmi, and Balley (2007) stated that the ways teachers and students interact with each other in the social context of mathematics classroom are important to student learning. In addition, Moschkovich (1999) noted that students are expected to engage in classroom interactions and develop mathematical thinking, such as making reasons, describing conjectures, and clarifying ideas.

Considering the Iranian context, teacher-student interactions have been characterised by teachers doing most of the talking in a mathematics classroom and leaving little space for student-to-student talk. In such context, classroom interactions are mainly built on close questions teachers give students to work through from their textbooks, rules teachers give students to remember, abstract calculation and procedures teachers explain to students, and the correct answer teachers emphasise. In this way, classroom interaction has been limited to questions teachers raise, short responses students give, and the definite responses teachers provide the class with. The pattern of teacher-student interactions the Iranian students have experienced discouraged student mathematical understanding and worked against mathematical thinking because students are not encouraged to participate in classroom discussions, explain their ideas, provide evidence, and make argumentation. In other words, classroom interaction is all about listening to teacher talk and remembering rules. The fact is that in Iranian high school settings teachers are prone to follow textbooks, to be loyal to the course program (Sepasi, 2000), and students have already remained passive recipients of knowledge (Kamyab, 2004).

In this paper, I adopt the sociocultural perspective on learning and consider two questions as I review mathematics education literature related to patterns of teacher-student

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interactions. First, what can we learn from research on a particular pattern of teacher-student interactions? For instance, does a particular pattern of classroom interaction support student conceptual understanding, and, if so, how? Second, what do teachers do to productively support classroom interactions? Finding answers to these questions from research studies is important for my future study because I want to examine the patterns of teacher-student interactions in Iranian mathematics classrooms. I aim to understand how similar or different patterns of classroom interactions in the Iranian classrooms are from those identified by research literature.

The goal of this paper is to review research studies that investigated patterns of teacher-student interactions in mathematics classroom (e.g., Mehan, 1979), and to examine the studies (e.g., Moschkovich, 1999) that offer findings from an empirical study they made about instructional strategies teachers use to support productive patterns of teacher-student interactions.

It is worth examining patterns of teacher-student interactions through this overview of literature due to two reasons. First, this overview made me aware of particular patterns of teacher-student interactions used in the Western context that might be similarly used in the Iranian context. Second, as a result of reviewing these patterns of classroom interaction, I came to understand effective strategies that Western teachers used to promote productive patterns of classroom interaction. In my future study, I will consider whether and how Iranian teachers use the similar or different strategies to develop productive patterns of classroom interaction.

Learning Theory

The view of learning from sociocultural perspective is consistent with the Vygotskian perspective, which emphasises the role of classroom interaction in student learning (Vygotsky, 1978). To Vygotsky, learning involves the sharing of meanings as the learner interacts with more competent peers. Vygotsky (1978) made his idea of learning clear through the term "Zone of Proximal Development" (ZPD). He defined the ZPD as "the distance between the actual development level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers" (p. 86).

The idea is that learners learn best as they engage in working with more skilled persons, and it is through such joint engagement that learners acquire new concepts. I can infer that the function of ZPD is to involve the learners' collaboration when they solve the problem. The aim of the collaborative endeavor is to enable the learners to solve problems that cannot be solved in the absence of competent peers. This aim requires the teacher to adopt and support a particular pattern of classroom interaction that encourages the learners to make their thought explicit as they participate in sharing ideas, making reasons, and providing a conclusion. If we draw on Vygotsky's notion of ZPD claiming that learning is dependent on the learners' interaction with more competent peers, then, we need to identify particular forms of classroom interactions that are more likely to facilitate the student learning through collaborating with skilled persons.

Similarly, Lave (1988) and Wenger (1998) conceptualised learning as being inherently social. They viewed learning as a matter of participating in the classroom practice as the learners interact and learn together. To Lave and Wenger, the concept of practice indicates doing in a social context that gives meaning to what the learners do.

There has been growing interest in several studies that have shed light on teacher-student interactions from sociocultural perspective and the way in which student learning is

enhanced in a whole-class discussion (Goos, 2014; Razfar, 2012; Stein, Engle, Smith, & Hughes, 2008; Ball, Goffney, & Bass, 2005; Civil & Planas, 2004; Engle & Conant, 2002).

For the purpose of this paper, I want to focus on productive patterns of classroom interaction that can help students to develop a better conceptual understanding. The productive pattern of teacher-student interaction has been defined as a "purposeful talk on a mathematics subject" (Pirie & Schwerzenberger, 1988, p.460). Guiding the development of the purposeful talk requires teachers to take a significant role in a mathematical classroom ensuring all students actively engage in it. Kazemi (1998) characterised productive pattern as a form of classroom interaction in which the development of student's mathematical thinking had been supported. That is, we will consider a mathematical classroom productive if student outcome resulting from teacher-student interaction enables them to make reasoning that justifies procedures rather than statements of the procedures themselves, and to make relations among multiple strategies (Kazemi, 1998).

Patterns of Teacher-Student Interactions in the Mathematics Classroom

Overview of studies in which patterns of teacher-student interactions are examined can enable me to infer whether and how patterns of interaction in the Iranian classrooms look more like this or that pattern explored in research studies. In addition, this can help me identify the messages that teachers and students might form in my future study, where a different or similar pattern of interaction may emerge with respect to the Iranian classroom.

Mehan (1979) analysed a particular pattern of classroom interaction that minimised the opportunities for students to participate fully in classroom discussions. He found that the predominant pattern of turn-taking often involves teacher's evaluation who normally initiates the sequence by questions requiring mathematical fact recall. The turn sequences in this pattern have three parts including teacher Initiation (I), student Response (R), and teacher Evaluation (E).

Within this pattern of turn-taking (IRE), students must develop particular strategies to perform well (Mehan, 1979) because the pattern requires the students to respond to the teacher's initiation not only with the correct content but also with the correct communicative conventions; otherwise, the student's response may be disregarded by the teacher (Mehan, 1979). In addition, students need to know when and how to respond, and what kinds of questions teachers are asking when they initiate the sequence. This pattern has been criticised from different points of view. For example, the IRE disadvantages the students from cultures where this form of classroom interaction is uncommon (Tharp & Gallimore, 1988); and it provides little opportunity for students to verbalise their thought or comment on their peers' ideas (Wood, 1992). In contrast, Wells (1993) noted that evaluation is the most typical function of the third move.

According to Scott, Mortimer, and Aguiar (2006), the IRE pattern requires the teacher to take *authoritative* interaction approach, presenting a certain point of view, leading students through a question and answer routine, and creating a close pattern of interaction. Through authoritative approach, the teacher does most of the talking, allowing little space for students to express their ideas. Scott, Mortimer, and Aguiar (2006) added that more than one voice may be heard in authoritative interaction but there is no exploration of various points of view.

Some researchers have assessed another pattern of classroom interactions that is built on the Initiation, Response, and Follow-up (IRF). This pattern begins with either a student or the teacher posing a question or initiating a topic. Then, the initiator takes the response to

move the conversation forward. Next, the conversation continues for as long as the teacher and students wish to talk about the topic (Anneberg Learner Media Organization, 2004).

While some researchers have mentioned that the IRF promotes student understanding, others noted that it can constrain student learning. For example, some researchers noted that the IRF reflects a narrow mode of knowledge transmission and cannot facilitate student understanding (Orsolini & Pontecorvo, 1992; Tharp & Gallimore, 1988). The idea is that such a dominant pattern of teacher-student interactions, in which the third-turn follow-ups is on the part of the teacher, is basically teacher-oriented and can be problematic in providing students with opportunities to develop communicative competence (Nassaji & Wells, 2000).

In contrast, some researchers (see, for example, Mercer, 2000) noted that using follow-up turn leads in a stronger communicative base. Christie (2002) mentioned that rejecting the pattern in which follow-up is supported delivers a message about a tendency to neglect looking at the nature of meanings in constructing ideas, roles of teachers and students at the time of constructing shared meanings, and the importance of such pattern in enabling students to develop a better understanding.

Using the IRF pattern in the classroom, the teacher adopts a *dialogic* interaction approach in teaching, making a sequence of prompts, using probing questions to engage students in an ongoing discussion, and creating an open pattern of teacher-student interaction. The dialogic approach allows the student to come to a new idea through the process of exploring and talking. Throughout the lessons, students have a degree of agency to provide hypotheses, explain ideas, pose questions, and provide reasons.

In dialogic approach, there is an attempt to work on student's views in a way that the teacher might adopt an approach that allows for comparing and contrasting ideas. The teacher, then, tries to make explicit how those ideas are relevant to one another. In this way, students are provided with opportunities to connect their ideas to each other. The teacher evaluates these ideas so as to prompt others to engage in discussions and offer different interpretations of the event. Here, an important point is that the direction of progress of whole-class interactions is impacted not only by the teacher but also by students' contributions.

According to Aguiar and Mortimer (2003), the *transition* between authoritative and dialogic approach supports meaningful learning as different teaching objectives are addressed. The extent of transition between authoritative and dialogic approaches might be related to the teachers' perspective of teaching and learning. The point is that teacher decision of the transition between dialogic and authoritative approach must lead to student conceptual understanding.

Consequence of Teacher-Student Interaction Approach to Student Learning

The consequence of authoritative and dialogic interaction patterns to student learning is tied to their merits and demerits. The merit of authoritative approach depends on the purpose it is used to serve on particular occasions. For instance, mathematical practices involve certain goals, such as solving a word problem, focusing on mathematical content, acquiring technical terms, or understanding mathematics textbooks within an overall lesson sequence. Drawing on this, the teacher uses certain strategies, supporting students to bring various ways of talking. During a classroom practice such as acquiring technical terms, the initial discussions may follow the authoritative pattern of interaction, but the further conversational turns may not follow this pattern when the instructional goal is to focus on mathematical content. The former objective allows the teacher to elicit the correct response and save time to uncover more mathematical content.

Despite this merit, the authoritative approach is not free from instructional shortcomings. The first shortcoming of this approach is that it does not support the conceptual goal of constructing knowledge (Wells & Mejia-Arauz, 2006). This might be because of the fact that this approach doesn't fully support student-to-student talk and students are provided with little opportunities to express their ideas and make reasoning.

The second shortcoming is that authoritative approach does not encourage student's justification of their ideas and hence limits student's effort to develop argumentation. From the sociocultural perspective, if learning is viewed as opposed to constructing arguments, then the value of mathematical reasoning is devalued. In addition, some researchers argued that if students are not encouraged to think on their own, they do not develop complex thinking skills in mathematics learning (Cobb, Bowers, 1999; Voigt, 1995).

In contrast to authoritative approach, the dialogic approach has potential to engage students in more interactive patterns of interactions, supporting students to think about their solutions, evaluate ideas, justify explanations, and provide reasoning. In the one hand, such pattern of interaction enjoys the merit of developing mathematical thinking as students participate in whole-class discussions. On the other hand, developing mathematical thinking skills may take students a great deal of time during the school semester. That is, covering instructional goals in a classroom where the teacher takes dialogic approach might not be achievable during the intended time. I can infer that to achieve instructional goals teachers need to constantly shift between dialogic and authoritative approaches so that they can save time, cover more mathematical content, and develop student learning.

In addition to constantly shift between the approaches of classroom interactions to support student learning, there are productive instructional strategies that can help develop student conceptual understanding. Through the review of literature, I focus on the strategies that had been widely and rarely documented in research studies because it can ensure me that the instructional strategies the Iranian teachers use are more likely to fall between such extreme ranges.

Productive Instructional Strategies

I reviewed research studies in which researchers had examined instructional strategies that productively supported patterns of teacher-student interactions. That is, the strategies supported classroom interaction in ways that lead in student understanding.

For instance, in Moschkovich's study (1999), the teacher used particular instructional strategies (that are widely-documented in similar research studies, see, for example, Goos, 2004; Engle & Conant, 2002, Kazemi, 1998) including mathematical linguistics clue, revoicing, comparison, and contrasting, to encourage student-to-student talk and help students to reflect upon each other's contributions. The teacher also kept the discussion ongoing by asking students for making hypotheses, prediction, justification, clarification, argumentation, and summarising. Moschkovich concluded that these strategies can provide students with opportunities to actively participate in discussions, develop conceptual understanding, and uncover the mathematical content.

Loef Franke, Kazemi, and Battey (2007) examined different effective strategies that teachers can use to support student understanding. In their study, out of several certain strategies (e.g., revoicing, aligning students on the basis of their ideas, highlighting positions, pointing out an implicit aspect of student explanation) proven to be productive in supporting teacher-student interactions, I choose filtering approach that is rarely addressed in similar studies I reviewed. It is the way that helps the students to make details explicit in their explanation. Using this approach, the teacher can focus students' attention on a certain idea.

In this approach, students are encouraged to share their solutions and assess one another's ideas. It is followed by the teacher's filtering, choosing which idea worthwhile pursuing with the whole class. Through this structured way that teachers use to interact with the whole class, students are given opportunities to value and discuss solutions, producing more meaningful and productive discussions. In addition, this approach allows the students to self-evaluate their solution and reproduce more valuable ideas. In this way, they can develop sophisticated thinking skills because they need to figure out what the weakness of their solution is and how they can come to a better solution.

Conclusion

First, I provide a view of classroom interactions from researchers' point of view who adopt sociocultural perspective on learning. I then characterise the ways teachers and students interact in the Iranian context where classroom interactions is dominated by the teacher talk. Next, I draw on the work of Vygotsky, describing the term ZPD and its connection to teacher-student interactions. After that, I review the features of productive patterns of classroom interaction, describing that student outcome enables them to make reasoning. Evidence from research studies exist to support the need for promoting productive classroom interaction, guiding students to make sense of mathematical content. Further, in order to make clear the difference between more productive and less productive classroom interactions, I provide a dichotomy between "IRE" and "IRF" patterns of teacher-student interactions following authoritative and dialogic approaches. Finally, I draw on some researchers' work (e.g., Moschkovich, 1999; Loef Frank, Kazcmi, & Balley, 2007) who examined instructional strategies that have the potential to create conditions to develop productive patterns of teacher-student interactions. I review the strategies in order to understand how similar or different these instructional strategies are with what I may observe in the Iranian context, and whether the strategies can lead to a productive pattern of teacher-student interactions in Iran.

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